National Readmission Rates and Outcomes for Patients Discharged Against Medical Advice

Title: National readmission rates and outcomes for patients discharged against medical advice

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Purpose: Reducing non-elective readmissions is a strategic priority for hospitals. Individuals discharged against medical advice (AMA) are at high risk for readmissions. Previous studies on readmission outcomes after AMA discharge have been limited in their generalizability. This study sought to determine the likelihood of readmissions after AMA discharge, to identify factors associated with readmissions, and to assess in-hospital mortality, inpatient charges and length of stay for these readmissions.

Methods: Using the Agency for Healthcare Research and Quality (AHRQ) all-payer Nationwide Readmissions Database, we conducted a retrospective cohort analysis of 19,882,317 (95% CI: 12,232,775 – 20,535,955) weighted index admissions for patients ≥18 years admitted from January – November 2014. We calculated 30-day non-elective readmission rates, 30-day in-hospital mortality, lengths of stay, and hospital charges by discharge disposition. To assess differences in readmission rates by discharge disposition, we estimated multivariable logistic regression models and adjusted for patient, clinical, and hospital characteristics.

Results: Patients discharged AMA had a 30-day all-cause readmission rate of 21.0% (95% CI: 20.6 – 21.3) versus 10.4% (95% CI: 10.2 – 10.5%) for routine discharge to home or self-care. The difference remained significant ($p<0.001$) after adjusting for clinical, sociodemographic and hospital characteristics. Younger age, increased number of chronic comorbidities, low household income, and having public insurance were associated with higher readmission rates. Adjusted odds of 30-day in-hospital mortality was estimated to be 10% higher for patients discharged AMA versus routine discharge to home or self-care (aOR 1.10, 95% CI: 1.01 – 1.20). Leaving AMA resulted in the lowest hospital utilization ($p<0.001$), with a median 30-day total LOS of 5.8 days (IQR: 3.1 – 10.9) and total charges of $48,499 (IQR: $26,494 – $92,488).

Conclusions: The 30-day readmission rate was significantly higher for patients discharged AMA than for routine discharge to home or self-care. While patients discharged AMA had lower overall hospital utilization, in aggregate they had slightly higher adjusted in-hospital mortality. There is potential opportunity to both lower healthcare spending for lower-risk AMA patients and improve outcomes for higher-risk AMA patients. Future research should focus on better risk stratification of this patient population so that such targeted interventions may be implemented.

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Glossary Listing

- ACA: Affordable Care Act
- AHRQ: Agency for Healthcare Research and Quality
- AMA: against medical advice
- aOR: adjusted odds ratio
- CCS: Clinical Classifications Software
- CI: confidence interval
- HRRP: Hospital Readmissions Reduction Program
- IQR: interquartile range
- LOS: length of stay
- NRD: Nationwide Readmissions Database
- OR: odds ratio

Introduction

Hospital readmissions add significant health expenditures and are an indicator of poor care coordination.(1–4) Nearly 1 in 5 Medicare patients are readmitted to the hospital within 30 days at an estimated cost exceeding $17 billion, and over half of these patients did not visit an outpatient physician between the time of their initial discharge and re-hospitalization.(3) Several randomized prospective trials have shown that interventions such as patient education, pre-discharge assessments and home health care can decrease readmissions by 12-50%.(5) Such interventions aim to decrease avoidable hospital readmissions, which are attributable to sub-optimal patient care or medical errors and thus reflect a hospital's quality of care. Approximately 1 in 4 readmissions are "avoidable", implying that the majority of readmissions reflect underlying patient characteristics and not influenced by hospital practices.(6,7)

The Affordable Care Act (ACA) introduced the Hospital Readmissions Reduction Program (HRRP) in 2010 in an effort to improve coordination of care and lower healthcare spending. This program withholds up to 3% of Medicare payments to hospitals with higher-than-expected 30-day readmission rates for a growing list of selected clinical conditions. These conditions include acute myocardial infarction, heart failure, pneumonia, total hip or knee replacement, chronic obstructive pulmonary disease and coronary artery bypass graft surgery.(8) An observational study found that readmission rates for targeted conditions fell from 21.5% to 17.8% between 2007-15, with the most rapid declines occurring during the years of program implementation.(9)

Tying financial incentives to readmission rates has drawn increasing attention to clinical, socioeconomic and hospital characteristics that predict higher risk of readmission. Boston, which has more per-capita hospital beds than New Haven, has been found to have significantly higher readmission rates, irrespective of disease severity. This suggests that supply-side factors (e.g. number of hospital beds) may influence decisions to admit patients.(10) Further, numerous patient characteristics associated with higher readmission rates are not currently factored into Medicare's risk-adjustment criteria, such as black race, lower household income, having public insurance, increased burden of chronic comorbidities, lack of social support, and physical mobility limitations.(11,12) Since readmission rates are influenced by such non-modifiable factors, future work to identify high-risk patients would enable more accurate risk adjustment and targeted readmission reduction interventions.

Individuals discharged against medical advice (AMA) are a particularly vulnerable patient population with regards to readmissions. These are patients who voluntarily leave the hospital before discharge is recommended by their treating physicians, and they account for approximately 1-2% of all hospital discharges.(13–16) While rates of AMA discharges have not changed over time, patients leaving the hospital AMA are more often younger and male, have lower household incomes, are homeless, less likely to have physical comorbidity and more likely to have mental illness - often alcohol and drug abuse.(14,15) In one qualitative study, patients reported poor communication with clinicians, inadequate pain management, perceived poor bedside manner, and long wait times as factors that influenced their decision to leave AMA.(17) Across several studies, patients discharged AMA have higher rates of 30-day all-cause readmission (OR 1.35 - 2.10) and 30 to 90-day in-hospital mortality (OR 1.40 - 2.51), even after adjusting for clinical and socioeconomic confounders.(13,15,16,18–20)

While these studies are strongly suggestive of higher rates of readmission and worse outcomes for patients discharged from the hospital AMA, their generalizability may be limited by their single-site design or restriction to certain patient populations (e.g. Veterans Administration patients). In this study, we used a nationally representative, all-payer weighted survey database of discharges in the United States to determine the likelihood of readmissions after AMA discharge. Our secondary outcomes were to identify patient and hospital factors associated with readmissions, to assess in-hospital mortality, and to quantify inpatient charges and length of stay for readmissions.

Methods

Data Source

We conducted a retrospective cohort analysis of hospital readmissions using the 2014 all-payer Nationwide Readmissions Database (NRD) published by the Agency for Healthcare Research and Quality (AHRQ). This dataset captures all discharges at nonfederal public and private hospitals in 22 geographically dispersed states, including data from 2,048 community hospitals accounting for 51.2% of the total US population and 49.3% of hospitalizations. The 2014 NRD contains approximately 15 million unweighted discharges and approximately 35 million weighted discharges.(21) The Brigham & Women's Hospital Institutional Review Board reviewed and approved this study.

Study Cohort

We first identified index admissions as all hospitalizations for patients ≥18 years who were discharged between January – November 2014. The NRD collapses records for multiple hospitalizations that included transfers to an acute care hospital into a single discharge, with subsequent readmissions being attributed to the final discharging hospital. We excluded index admissions for obstetrical/newborn care given their high volume and different readmission risk profile versus medical/surgical admissions. We also excluded admissions if the patient died during the index hospitalization, or if there was a missing primary diagnosis and/or length of stay. Additionally, any non-elective readmission occurring within 30 days of the index discharge was not counted as an another index admission (22,23).

Defining Readmissions

We defined a readmission as a non-elective admission for any diagnosis within 30 days of an index admission. We excluded readmissions that were classified as elective in the administrative claim or with a primary procedure or diagnosis code for chemotherapy as these admissions are often part of a patient's intended treatment course.(21–23) Only the first readmission counted towards the 30-day readmissions rate. We included non-elective readmissions for any reason because patients might be admitted for related conditions even if the index admission and readmission diagnoses differ. To calculate the 30-day readmission rate, the numerator was the number of eligible index admissions with ≥1 eligible readmissions, and the denominator was the total number of eligible index admissions (defined above).

We conducted two sensitivity analyses on our 30-day readmissions rate by index admission disposition type. First, we excluded records in which the patient was transferred or if there were ≥3 transfers in a single day, as these could represent more complex patients requiring higher acuity care or potentially erroneous records. Second, we restricted readmission events to only those hospitalizations having the same multi-level CCS diagnosis as the index admission. This increased the likelihood that the second admission is in fact a readmission and not a second primary admission, though this methodology may have also underestimated readmissions. CCS is a tool for clustering ICD-9-CM codes into clinically meaningful diagnosis categories that has been previously reported in the literature.(24)

Secondary Outcomes

Secondary outcomes included 30-day in-hospital mortality rate, 30-day total length of stay (LOS) and charges associated with hospitalizations. Previous studies have reported that patients discharged AMA not only have shorter index admission LOS, but also higher rates of readmission, which may ultimately result in increased overall healthcare utilization. To approximate total healthcare utilization for an episode of care, we calculated 30-day total LOS or charges as the sum of LOS or charges, respectively, for an index admission and all subsequent readmissions within a 30-day period. The top 10 most common Clinical Classifications Software (CCS) diagnosis groups were tabulated across readmissions among AMA versus all other index discharges to identify the most common reasons for readmission.

Patient and Clinical Characteristics

We evaluated associations of readmission rates with patient clinical (comorbid chronic conditions) and sociodemographic (gender, age, insurance status, household income) characteristics, as well as hospital factors (bed size, teaching status, metropolitan vs. rural, public vs. private ownership). We used the Chronic Condition Indicator (CCI) to dichotomize approximately 14,000 ICD-9-CM codes into chronic or non-chronic conditions and to aggregate chronic conditions into 18 mutually exclusive groups, as previously described.(22) We included all CCI groups as independent covariates in our analysis, and also adjusted for the total number of CCI groups for each index admission as an indicator of medical complexity.(23,25,26)

Statistical Analyses

To assess differences in readmission rates by discharge disposition, we estimated multivariable logistic regression models predicting non-elective readmissions from discharge disposition alone. We also adjusted for patient, clinical, and hospital characteristics (age, gender, chronic comorbidities, household income, insurance status, hospital size, ownership, teaching status). For LOS and hospital charges by index admission disposition, we estimated multivariable ordinary linear regression models predicting log-transformed LOS or charges, using the patient, clinical, and hospital characteristics mentioned above.(27) For estimation of all frequencies, rates, and regressions, post-stratification weights were used, with variance calculations that appropriately account for the stratified cluster design of the NRD.(27,28) In each analysis, we calculated robust standard errors and 2-sided tests at a significance level of 0.05, appropriately accounting for the design of the NRD. Block tests with multiple degrees of freedom were used to determine the significance of each fixed effect with >2 levels. Statistical analysis was performed using SAS 9.4 (SAS Institute, Inc., Cary, NC).

Results

Among 19,882,317 (95% CI: 12,232,775 – 20,535,955) weighted index admissions, 1.5% (95% CI: 1.4 – 1.5%) of them resulted in an AMA discharge (n = 291,994, 95% CI: 275,044 – 308,944). Other common dispositions for index admissions included routine discharge to home or self-care (65%, 95% CI: 64.5 – 65.6%), transfer to other facilities such as rehabilitation centers or skilled nursing facilities (16.7%, 95% CI: 16.4 – 17.0), and home health care (15.7%, 95% CI: 15.2 – 16.2).

Readmission and mortality rates by index disposition

Across all weighted index admissions, the overall 30-day all cause readmission rate was 12.1% (95% CI: 11.9 – 12.2%). Unadjusted 30-day readmission rates were significantly different across discharge categories (p<0.001). The unadjusted 30-day readmissions rate for AMA discharges was 21.0% (95% CI: 20.6 – 21.3) versus 10.4% (95% CI: 10.2 – 10.5%) for routine discharges to home **[Table 1]**. This difference remained statistically significant (p<0.001) after adjusting for patient clinical, sociodemographic and hospital characteristics **[Table 8].**

Across all weighted index admissions, the overall 30-day in-hospital mortality rate was 5.6% (95% CI: 5.4 – 5.7%). The unadjusted 30-day in hospital mortality rate for AMA discharges was 2.5% (95% CI: 2.3 – 2.7%) versus 3.4% (95% CI: 3.3 – 3.5) for routine discharges to home **[Table 1]**. After adjusting for patient and hospital characteristics, odds of 30-day in-hospital mortality was estimated to be 10% higher for patients discharged AMA versus routine discharge to home (aOR 1.10, 95% CI: 1.01 – 1.20). Other covariates associated with higher in-hospital mortality rates in the adjusted model include age ≥65 years, male gender, increased number of chronic comorbidities, private insurance status, higher household income and rural location of hospital (p=0.007 for household income, p<0.001 for all other block tests) **[Table 9]**.

Sensitivity analyses of 30-day readmission rates revealed similar trends. After excluding index discharges involving same-day hospital transfers and records involving ≥3 same day stays, the 30-day readmission rates for AMA discharges and all discharges did not differ significantly **[Table 3]**. Restricting readmissions to only include hospitalizations in which the multi-level CCS diagnosis matched that of the index admission produced 30-day readmission rates of 9.1% (95% CI: 8.9 – 9.4) for AMA versus 3.5% (95% CI: 8.9 – 9.4) for routine discharges to home (p<0.001) **[Table 4]**.

Readmission rates by patient and hospital characteristics

In bivariate analysis of readmissions after AMA discharge, 30-day readmissions varied significantly by age, gender, comorbid chronic conditions, household income, insurance type, bed size of hospital, hospital urban/rural location, and teaching status (p<0.001 on global test of the null hypothesis) **[Table 7]**.

These covariates remained statistically significant in the full multivariate logistic regression model (Model #3, p<0.001 on global test of the null hypothesis) **[Table 9]**. Patients discharged AMA had greater odds of 30-day readmission after adjusting for age, gender and chronic comorbidities (Model #1 aOR 2.32, 95% CI: 2.27 – 2.37). This effect was decreased after additional adjustment for patient sociodemographic characteristics such as household income and insurance status (Model #2 aOR 2.15, 95% CI: 2.10 – 2.19). It remained unchanged after additional adjustment for hospital characteristics such as size, public vs. private ownership and teaching status (Model #3 aOR 2.15, 95% CI: 2.11 – 2.19).

In the full multivariate model (Model #3), several other covariates were associated with higher risk of 30-day readmissions **[Table 9]**. Odds of 30-day readmissions were higher for patients <65 years, male patients (aOR 1.04, 95% CI 1.03 – 1.05), patients with an increasing number of chronic comorbidities (4+ CCIs aOR 1.39, 95% CI 1.35 – 1.42), patients in the lowest household income quartile (1st quartile aOR 1.09, 95% CI 1.07 – 1.11), and patients with Medicare (aOR 1.66, 95% CI 1.63 – 1.69) or Medicaid (aOR 1.73, 95% CI 1.70 – 1.77) insurance. Odds of 30-day readmissions were lower for small-sized hospitals (aOR 0.93, 95% CI 0.90 – 0.96) and hospitals in non-metropolitan areas (aOR 0.85, 95% CI 0.82 – 0.88).

Length of stay and cost of readmissions

Across all weighted index admissions, median LOS was 4.4 days (IQR: 2.2 – 8.3) and median hospital charges were $31,252 (IQR: $16,399 – $62,680). Median 30-day total LOS was 9.7 days (IQR: 5.9 – 16.1) and median 30-day total hospital charges were $71,908 (IQR: $40,542 – $130,921) across all index admissions. 30-day healthcare utilization differed across index disposition categories (p<0.001). AMA discharges had the lowest utilization, with a median 30-day total LOS of 5.8 days (IQR: 3.1 – 10.9) and total charges of $48,499 (IQR: $26,494 – $92,488) **[Table 5]**. In multivariate regression after adjusting for patient and hospital characteristics, AMA discharge status was still associated with shorter LOS and lower hospital charges in a 30-day period **[Table 9]**.

Readmission admission diagnoses

Readmission diagnoses differed between patients initially discharged AMA versus all other disposition **[Table 6]**. Among the top 10 multi-level CCS diagnoses across all readmissions were diseases of the heart, bacterial infection, non-specific healthcare-related complications, mood disorders, diseases of the urinary system, and diabetes mellitus with complications. Several diagnoses were more common among patients after AMA discharge. These included alcohol-related disorders (9.4% of readmissions; 95% CI 8.3 – 10.5%), skin and subcutaneous tissue infections (4.3% of readmissions, 95% CI 4.0 – 4.6), substance-related disorders (3.7% of readmissions, 95% CI 2.8 – 4.5) and pancreatic disorders not related to diabetes mellitus (2.9% of readmissions, 95% CI 2.7 – 3.2).

Discussion

In this nationally representative sample of hospital discharges, 1.5% (95% CI: 1.4 – 1.5%) of weighted index discharges involved patients discharged AMA. Twenty one percent (95% CI: 20.6 – 21.3%) of patients leaving the hospital AMA were readmitted within 30 days, compared to 10.4% (95% CI: 10.2 – 10.5) of those discharged routinely to home or self-care. After adjusting for patient and hospital characteristics, patients discharged AMA had an OR of 2.15 (95% CI: 2.11 – 2.19) for 30-day readmission compared to those discharged to home.

Several readmission diagnoses were more common for patients discharged AMA. These included alcohol and substance-related disorders, skin and subcutaneous tissue infections, and pancreatic disease. Patients discharged AMA also had significantly shorter 30-day total in-hospital LOS and lower 30-day total hospital charges compared to patients discharged home. However, on adjusted multivariate analysis, patients discharged AMA had slightly higher rates of 30-day in-hospital mortality (aOR = 1.10, 95% CI: 1.01 – 1.20).

These results largely corroborate previous reports that patients discharged AMA are at higher risk of readmission.(13,15,16,18–20) While other studies on AMA discharges and readmissions have been limited to single payers or hospital sites, our research presents data on an all-payer, nationally representative adult patient cohort. Our estimated increased odds of 30-day readmission for AMA patients was in line with previous literature, which reported 1.35 – 2.5 times the increased risk.(13,15,16,18,20) Notably, when restricting our analysis to just the readmissions with the same diagnosis as the index admission, the relative risk of 30-day readmission for AMA versus routine discharge to home or self-care increased (9.1 vs. 3.5%, respectively). Another study reported that AMA patients are readmitted at an accelerated rate in the first 15 days, and 95% of those readmissions were for the same diagnosis as the index admission.(20) These data suggest that AMA readmissions are more likely to be bounce back admissions for the same, previously inadequately treated condition.

Our findings of a 10% increase in adjusted 30-day in-hospital mortality for patients discharged AMA was lower than prior estimates suggesting a 2-fold increased mortality over this duration. This discrepancy could reflect methodological differences, as these reports estimated mortality rates from public death records (e.g. social security index).(13,15) In-hospital mortality may significantly underestimate true mortality rates for patients discharged AMA, as they are more likely to be homeless, face barriers to accessing care, and prone to die from drug overdoses outside of the hospital.(19)

Though 1 in 5 patients discharged AMA are readmitted within 30-days and face higher in-hospital mortality risk, these results challenge the assumption that all patients discharged AMA are causing themselves harm. Nearly 80% of patients who leave the hospital AMA are not readmitted within 30 days. Their overall health resource utilization for a 30-day period after index admission is significantly lower than for patients discharged routinely to home or self-care. Using empirical data from our study population, if we assume that the 291,994 index admissions resulting in AMA discharges were instead routine discharges to home, this would create nearly 730,000 additional days in the hospital for index admissions and readmissions at a total cost of $4.2 billion annually.

This hypothetical analysis highlights the potential cost savings for shared decision making between providers and patients who may wish to leave the hospital AMA. Our data revealed that up to 80% of patients discharged AMA do not return to the hospital within 30 days, suggesting that these individuals may be appropriately discharged earlier in their hospitalization. If these relatively lower-risk patients can be identified, caregivers can start discharge planning earlier, setting up outpatient primary care visits and favoring outpatient substance abuse rehabilitation over inpatient detoxification. As inadequate drug addiction and pain management are the most common reasons why patients leave AMA, directly addressing these as a part of their outpatient management plan may improve care coordination and patient satisfaction.(17)

However, implementing such a strategy will rely on accurately predicting which patients are higher-risk and more likely to be in the 21% readmitted within 30 days. Overall, patients discharged AMA still have higher in-hospital mortality rates on readmission, and face many sociodemographic disparities that make them a vulnerable patient population. Several studies have sought to identify which of the patients leaving AMA are at highest risk for readmission. Our data showed that younger age, male gender, increased number of chronic comorbidities, being in the lowest income quartile, and having public health insurance are associated with higher readmission rates. Conversely, smaller hospital size and rural location are correlated with lower readmission rates. Previous literature report male gender, having a history of alcohol abuse, and prior history of leaving AMA are associated with higher risk of readmission.(19,20)

These data must be understood in the context of the sociodemographic factors that lead patients to leave hospitals AMA. Simply because 21% of patients are readmitted within 30 days does not imply that the remaining 80% lack a clinical indication for hospital admission. These patients often face structural barriers to accessing care in both outpatient and hospital settings, such as poor insurance coverage, lower socioeconomic status, and history of addictions and mental health disorders.(29) Further, even if hospital quality of care were exactly the same for AMA versus all other patients, lack of outpatient follow-up with primary care physicians for these patients may increase their risk for readmissions.(13)

Limitations

These findings must be interpreted in the context of our study design. As with all readmission studies, it is difficult to determine the relatedness of readmissions after an index admission. We used temporality as a proxy for relatedness, and defined readmissions as any hospitalizations that started within 30 days of an index admission discharge, a methodology commonly used in the literature.(9) This approach also reflects how the Medicare Readmissions Reduction Program calculate readmission rates. Their penalties only apply to a limited number of conditions on index admission, and it does not distinguish between readmission diagnoses - all readmissions for the defined patient population within 30 days count towards a hospital's readmission rate.(8)

This dataset does not capture receipt of outpatient care, which is known to be associated with readmission risk.(30,31) In addition, this dataset only reports in-hospital mortality, which may significantly underestimate mortality for the patient population that leaves AMA. The NRD is limited to one year of historical discharge data and patient linkage numbers do not track across years, so follow-up time for patient outcomes after index discharge is limited. Thirty-day mortality rate may be insufficient, other studies have reported 90-day or even 12-month mortality rates for AMA patients.

Conclusion

Patients discharged from the hospital AMA have higher 30-day readmission rates than those discharged routinely to home, as well as lower healthcare utilization, as defined by total charges and LOS during this period. However, after adjusting for patient and hospital characteristics, individuals discharged AMA face slightly higher risk of 30-day in-hospital mortality. There is a potential opportunity to achieve cost savings through appropriate earlier discharge of lower risk patients who ultimately leave AMA. Conversely, providers and health systems should also implement targeted interventions to reduce readmissions and mortality for the highest risk individuals who leave AMA and face higher odds of poor outcomes. These may include pre-discharge education, substance abuse treatment, and outpatient primary care follow-up.(29) Further studies should aim to develop better risk stratification of patients discharged AMA in order to implement this multi-pronged approach to improve health outcomes for this vulnerable patient population.

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Tables & Figures

Table 1: weighted index admissions, by disposition

Index Disposition	Count of index admissions	95% CI	Percent of total	95% CI
Discharged to home or self-care	12,932,624	12,496,009 – 13,369,239	65.0	64.5 – 65.6
Transfer: short-term hospital	201,763	188,192 – 215,334	1.0	0.9 – 1.1
Transfer: other type of facility	3,321,394	3,204,164 – 3,438,624	16.7	16.4 – 17.0
Home health care	3,124,743	2,976,091 – 3,273,395	15.7	15.2 – 16.2
Against medical advice	291,994	275,044 – 308,944	1.5	1.4 – 1.5
All discharges[1]	19,882,317	19,230,727 – 20,533,907	100.0	100.0– 100.0

[1] Includes 9,798 (95% CI: 7,805 – 11,791) index admissions representing 0.05% of the total (95% CI: 0.04 – 0.06%) where patient was discharged alive, but disposition was unknown.

Table 2: 30-day readmissions rate and mortality rate, by disposition

Index Disposition	30-Day All Cause Readmission Rate, per 100 Index Admissions (95% CI)[1]	Readmissions Rate Odds Ratio (95% CI)	30-Day In-Hospital Mortality Rate[1]	Mortality Rate Odds Ratio (95% CI)
Discharged to home or self-care	10.4 (10.2 – 10.5)	Reference	3.4 (3.3 – 3.5)	Reference
Transfer: short-term hospital	17.2 (16.6 – 17.8)	1.79 (1.71 – 1.87)	6.9 (6.4 – 7.4)	2.13 (1.97 – 2.30)
Transfer: other type of facility	15.3 (15.0 – 15.5)	1.56 (1.53 – 1.58)	10.7 (10.4 – 10.9)	3.42 (3.32 –3.51)
Home health care	14.5 (14.2 – 14.9)	1.47 (1.44 – 1.50)	6.4 (6.2 – 6.6)	1.95 (1.90 – 2.00)
Against medical advice	21.0 (20.6 – 21.3)	2.29 (2.24 – 2.34)	2.5 (2.3 – 2.7)	0.73 (0.68 – 0.80)
All discharges[2]	12.1 (11.9 – 12.2)	--	5.6 (5.4 – 5.7)	--

[1] To assess whether readmission rates varied by index discharge disposition, *P* value from multiple degrees of freedom block test of discharge dispositions was calculated from logistic regression models predicting non-elective readmission or mortality at readmission from discharge disposition. Discharge disposition was significantly associated with non-elective readmission rate and readmission mortality rate with $P<.001$ for each.

[2] Includes readmissions for index charges where patient was discharged alive, but disposition was unknown. For this group, 30-day readmission rate was 6.0 (95% CI: 4.6 – 7.4%) and 30-day in-hospital mortality rate was 9.6% (95% CI: 6.6 – 12.6%).

Table 3: sensitivity analysis of readmission rate after excluding transfer patients

	Baseline		**Excluding index discharges involving any transfers**		**Excluding index discharges involving ≥3 same day stays**	
Index Disposition	30-Day All Cause Readmission Rate (per 100 index admissions)	95% Confidence Interval	30-Day All Cause Readmission Rate (per 100 index admissions)	95% Confidence Interval	30-Day All Cause Readmission Rate (per 100 index admissions)	95% Confidence Interval
Discharged to home or self-care	10.4	10.2 – 10.5	10.3	10.2 – 10.5	10.4	10.2 – 10.5
Transfer: short-term hospital	17.2	16.6 – 17.8	16.6	16.0 – 17.1	17.1	16.4 – 17.7
Transfer: other type of facility	15.3	15.0 – 15.5	15.2	15.0 – 15.4	15.2	15.0 – 15.5
Home health care	14.5	14.2 – 14.9	14.6	14.3 – 14.9	14.5	14.2 – 14.9
Against medical advice	21.0	20.6 – 21.3	20.8	20.5 – 21.2	20.9	20.6 – 21.3
All discharges[1]	12.1	11.9 – 12.2	12.0	11.8 – 12.2	12.1	11.9– 12.2

[1] Includes readmissions for index charges where patient was discharged alive, but disposition was unknown. For this group, 30-day readmission rate after excluding all transfers was 7.7 (95% CI: 6.3 – 9.0%) and 30-day readmission rate after excluding ≥3 same day stays was 6.0% (95% CI: 4.6 – 7.4%).

Table 4: sensitivity analysis of readmission rate conditional on readmission diagnosis being the same as index discharge diagnosis

	Baseline		**Only including readmissions with same multi-level CCS diagnosis as index admission**	
Index Disposition	30-Day Readmission Rate (per 100 index admissions)	95% Confidence Interval	30-Day Readmission Rate (per 100 index admissions)	95% Confidence Interval
Discharged to home or self-care	10.4	10.2 – 10.5	3.5	3.4 – 3.6
Transfer: short-term hospital	17.2	16.6 – 17.8	6.6	6.2 – 6.9
Transfer: other type of facility	15.3	15.0 – 15.5	3.0	3.0 – 3.1
Home health care	14.5	14.2 – 14.9	3.5	3.4 – 3.5
Against medical advice	21.0	20.6 – 21.3	9.1	8.9 – 9.4
All discharges[1]	12.1	11.9 – 12.2	3.5	3.5 – 3.6

[1] Includes readmissions for index charges where patient was discharged alive, but disposition was unknown. For this group, 30-day readmission rate conditional on readmissions having the same multi-level CCS diagnosis as index admission was 1.9% (95% CI: 1.4 – 2.5%)..

Table 5: Median LOS and hospital charges for index admission & total of index + 30-day readmissions

Index Disposition	**Index admission median LOS (IQR), in days**	**Index + 30-day readmissions sum total median LOS (IQR), in days**	**Index admission median charges (IQR)**	**Index + 30-day readmissions sum total median charges (IQR)**
Discharged to home or self-care	4.0 (2.0 – 7.6)	8.3 (5.1 – 13.6)	$29,028 ($15,385 – $57,959)	$62,951 ($36,258 – $111,683)
Transfer: short-term hospital	5.2 (2.4 –10.8)	10.4 (5.5 – 19.5)	$37,559 ($17,567 – $83,638)	$76,557 ($40,248 – $156,426)
Transfer: other type of facility	5.3 (2.8 – 9.6)	13.1 (8.4 – 21.1)	$35,557 ($18,662 – $70,502)	$92,081 ($51,968 – $167,642)
Home health care	4.7 (2.5 – 8.8)	11.2 (7.1 – 18.1)	$33,933 ($17,947 – $67,448)	$85,699 ($48,855 – $154,005)
Against medical advice	3.4 (1.6 – 7.1)	5.8 (3.1 – 10.9)	$26,476 ($13,276 – $56,889)	$48,499 ($26,494 – $92,488)
All discharges[1]	4.4 (2.2 – 8.3)	9.7 (5.9 – 16.1)	$31,252 ($16,399 – $62,680)	$71,908 ($40,542 – $130,921)

[1] Includes readmissions for index charges where patient was discharged alive, but disposition was unknown. For this group, median index admission LOS was 4.4 days (IQR: 2.3 – 8.9 days) and median total LOS for index + all 30-day readmissions was 10.6 days (IQR: 6.4 – 18.8 days). Median index admission hospital charges were $51,692 (IQR: $22,986 – $105,705) and median total hospital charges for index + all 30-day readmissions were $139,995 (IQR: $63,284 – $257,582).

Table 6: top 10 weighted readmission CCS2 diagnoses for AMA vs all other disposition

Readmissions with AMA as index disposition			**Readmissions with all other index disposition**		
Readmission diagnosis	*% of readmissions (95% CI)*	*Weighted national estimate of readmission volume (95% CI)*	*Readmission diagnosis*	*% of readmissions (95% CI)*	*Weighted national estimate of readmission volume (95% CI)*
1) Diseases of the heart	12.0 (11.5 – 12.5)	7,361 (6,845 – 7,876)	1) Diseases of the heart	13.6 (13.4 – 13.8)	317,917 (305,393 – 330,440)
2) Alcohol-related disorders	9.4 (8.3 – 10.5)	5,737 (4,875 – 6,599)	2) Bacterial infection	8.3 (8.1 – 8.5)	194,486 (186,851 – 202,121)
3) Diabetes mellitus with complications	5.2 (4.9 – 5.5)	3,187 (2,928 – 3,446)	3) Non-specific complications[1]	8.2 (7.9 – 8.4)	191,077 (180,108 – 202,047)
4) Bacterial infection	5.0 (4.7 – 5.3)	3,061 (2,833 – 3,289)	4) Diseases of the urinary system	5.8 (5.7 – 5.9)	136,244 (130,900 – 141,588)
5) Skin and subcutaneous tissue infections	4.3 (4.0 – 4.6)	2,629 (2,380 – 2,878)	5) Respiratory infections	3.8 (3.7 – 3.9)	88,231 (84,833 – 91,630)
6) Mood disorders	4.2 (3.8 – 4.6)	2,593 (2,285 – 2,900)	6) Lower gastrointestinal disorders	3.1 (3.1 – 3.2)	73,628 (70,587 – 76,668)
7) Substance-related disorders	3.7 (2.8 – 4.5)	2,245 (1,664 – 2,826)	7) Mood disorders	3.0 (2.8 – 3.2)	70,130 (64,235 – 76,026)
8) Non-specific complications[1]	3.1 (2.9 – 3.4)	1,913 (1,709 – 2,118)	8) COPD and bronchiectasis	2.6 (2.5 – 2.6)	59,640 (56,898 – 62,381)
9) Diseases of the urinary system	3.0 (2.7 – 3.2)	1,810 (1,657 – 1,963)	9) Respiratory failure; insufficiency; arrest	2.5 (2.4 – 2.6)	58,145 (55,588 – 60,703)
10) Pancreatic disorders (not diabetes)	2.9 (2.7 – 3.2)	1,780 (1,617 – 1,944)	10) Diabetes mellitus with complications	2.4 (2.3 – 2.4)	55,600 (53,059 – 58,140)

[1] Non-specific complications include: complications of implant, graft and device; complications of surgical/medical treatments

Table 7: Predictors of readmission among AMA versus all other discharge dispositions

Characteristic	Number of index admissions (95% CI)		30-day readmissions rate per 100 index admissions (95% CI)		Bivariate OR for all discharges (95% CI)
	AMA	Non-AMA	AMA	Non-AMA	
Age					
18-44	126,536 (117,989 – 135,082)	3,632,191 (3,479,881 – 3,784,502)	19.4 (18.9 – 19.8)	10.1 (9.9 – 10.3)	0.77 (0.76 – 0.78)
45-64	121,026 (113,941 – 128,111)	6,650,770 (6,409,174 – 6,892,365)	23.0 (22.5 – 23.5)	11.4 (11.2 – 11.6)	0.88 (0.87 – 0.89)
65+	44,433 (41,835 – 47,031)	9,307,361 (8,989,604 – 9,625,118)	20.0 (19.3 – 20.6)	13.0 (12.9 – 13.2)	Reference
Gender					
Female	108,623 (102,530 – 114,716)	10,418,664 (10,076,150 – 10,761,178)	20.0 (19.5 – 20.4)	11.6 (11.4 – 11.7)	Reference
Male	183,371 (172,142 – 194,601)	9,171,659 (8,864,004 – 9,479,313)	21.6 (21.2 – 22.0)	12.4 (12.2 – 12.5)	1.09 (1.08 – 1.09)
Median household income quartile					
1st quartile	114,828 (103,699 – 125,956)	5,526,622 (5,170,853 – 5,882,392)	21.8 (21.3 – 22.3)	13.0 (12.7 – 13.2)	1.18 (1.15 – 1.21)
2nd quartile	75,482 (70,228 – 80,737)	5,268,502 (5,027,397 – 5,509,607)	20.6 (20.2 – 21.1)	11.9 (11.7 – 12.0)	1.07 (1.04 – 1.09)

3rd quartile	53,052 (49,466 – 56,638)	4,453,547 (4,247,382 – 4,659,713)	20.5 (19.8 – 21.2)	11.4 (11.2 – 11.6)	1.01 (0.99 – 1.04)
4th quartile	42,658 (38,496 – 46,821)	4,021,218 (3,719,104 – 4,323,333)	20.1 (19.5 – 20.8)	11.3 (11.0 – 11.5)	Reference
Expected payer					
Private	43,560	4,854,145	15.8 (15.2 – 16.5)	7.8 (7.6 – 8.0)	Reference
Medicare	87,980	10,486,501	23.4 (22.9 – 24.0)	13.9 (13.7 – 14.0)	1.90 (1.86 – 1.93)
Medicaid	102,328	2,574,796	23.6 (23.1 – 24.1)	14.1 (13.8 – 14.3)	1.97 (1.92 – 2.02)
Other	57,735	1,651,381	16.5 (15.8 – 17.2)	8.6 (8.4 – 8.8)	1.14 (1.11 – 1.18)
Bed size of hospital					
Small	44,606 (38,449 – 50,763)	3,252,274 (3,038,694 – 3,465,854)	20.3 (19.4 – 21.1)	11.1 (10.7 – 11.4)	0.89 (0.86 – 0.93)
Medium	90,586 (79,581 – 101,591)	5,406,203 (5,087,669 – 5,724,737)	20.6 (20.0 – 21.1)	11.8 (11.6 – 12.1)	0.96 (0.93 – 0.99)
Large	156,802 (145,461 – 168,143)	10,931,845 (10,414,785 – 11,448,906)	21.4 (20.9 – 21.9)	12.2 (12.0 – 12.5)	Reference
Ownership of hospital					
Government	37,291 (31,497 – 43,086)	2,336,215 (1,990,290 – 2,682,139)	21.0 (20.0 – 22.1)	11.9 (11.6 – 12.2)	Reference
Private	254,703 (237,820 – 271,586)	17,254,108 (16,525,921 – 17,982,293)	21.0 (20.6 – 21.3)	11.9 (11.8 – 12.1)	1.00 (0.97 – 1.03)
Hospital teaching status					

Metropolitan teaching	178,181 (162,661 – 193,701)	12,238,239 (11,644,682 – 12,831,795)	21.7 (21.2 – 22.2)	12.1 (11.9 – 12.3)	Reference
Metropolitan non-teaching	89,000 (82,563 – 95,438)	5,385,419 (5,174,324 – 5,596,514)	20.6 (20.1 – 21.1)	12.0 (11.8 – 12.2)	0.99 (0.96 – 1.02)
Non-metropolitan	24,813 (22,505 – 27,122)	1,966,664 (1,834,145 – 2,099,184)	17.1 (16.1 – 18.2)	10.7 (10.4 – 10.9)	0.86 (0.83 – 0.90)
CCI sum indicator[1]					
0 or 1 CCI	64,144 (58,901 – 69,387)	2,419,984 (2,322,006 – 2,517,962)	14.4 (13.9 – 15.0)	6.2 (6.1 – 6.4)	Reference
2 CCIs	59,660 (55,586 – 63,733)	2,785,819 (2,685,236 – 2,886,402)	18.2 (17.6 – 18.7)	8.5 (8.4 – 8.7)	1.22 (1.20 – 1.24)
3 CCIs	57,058 (53,664 – 60,451)	3,626,224 (3,502,015 – 3,750,434)	20.6 (20.0 – 21.2)	10.3 (10.9 – 10.4)	1.33 (1.30 – 1.36)
4+ CCIs	111,133 (105,249 – 117,017)	10,758,295 (10,373,589 – 11,143,001)	26.4 (25.9 – 26.9)	14.7 (14.5 – 14.9)	1.44 (1.40 – 1.47)

[1] Each of the 18 CCIs were also included as independent covariates in the bivariate regression. All of the CCI categories reached statistical significance at p<0.001 except for CCI3 (endocrine, nutritional, metabolic & immunity; p=0.60) and CCI15 (perinatal conditions; p=0.12).

Table 8: Nested multivariate logistic regression of 30-day readmission rates

Characteristic	Model 1: Patient clinical characteristics		Model 2: Model 1 + patient socioeconomic characteristics		Model 3: Model 2 + hospital characteristics	
	Odds Ratio	95% CI	Odds Ratio	95% CI	Odds Ratio	95% CI
Index admission disposition status						
Transfer: short-term hospital	1.63	1.56 – 1.71	1.64	1.57 – 1.72	1.69	1.61 – 1.77
Transfer: other type of facility	1.36	1.34 – 1.38	1.32	1.30 – 1.34	1.32	1.30 – 1.34
Home health care	1.32	1.30 – 1.34	1.30	1.28 – 1.32	1.30	1.28 – 1.32
Against medical advice	2.32	2.27 – 2.37	2.15	2.10 – 2.19	2.15	2.11 – 2.19
Age						
18-44	1.14	1.12 – 1.15	1.31	1.29 – 1.34	1.30	1.28 – 1.32
45-64	1.00	1.00 – 1.01	1.18	1.17 – 1.20	1.18	1.17 – 1.19
65+	Reference		Reference		Reference	
Gender						
Female	Reference		Reference		Reference	
Male	1.03	1.02 – 1.03	1.04	1.03 – 1.04	1.04	1.03 – 1.05
CCI sum indicator[1]						
0 or 1 CCI	Reference		Reference		Reference	
2 CCIs	1.24	1.21 – 1.26	1.21	1.19 – 1.23	1.21	1.19 – 1.23
3 CCIs	1.35	1.32 – 1.38	1.30	1.28 – 1.33	1.31	1.28 – 1.33
4+ CCIs	1.44	1.40 – 1.48	1.38	1.35 – 1.42	1.39	1.35 – 1.42
Median household income quartile						
1st quartile			1.08	1.05 – 1.10	1.09	1.07 – 1.11
2nd quartile			1.01	0.99 – 1.03	1.02	1.00 – 1.05
3rd quartile			0.99	0.97 – 1.00	0.99	0.97 – 1.02
4th quartile			Reference		Reference	
Expected payer						
Private			Reference		Reference	
Medicare			1.66	1.62 – 1.69	1.66	1.63 – 1.69

Medicaid			1.74	1.71 – 1.78	1.73	1.70 – 1.77
Other			1.14	1.11 – 1.17	1.14	1.11 – 1.17
Bed size of hospital						
Small					0.93	0.90 – 0.96
Medium					0.98	0.95 – 1.00
Large					Reference	
Ownership of hospital						
Government					Reference	
Private					0.97	0.94 – 1.01
Hospital teaching status						
Metropolitan non-teaching					0.99	0.97 – 1.02
Metropolitan teaching					Reference	
Non-metropolitan					0.85	0.82– 0.88

[1] Each of the 18 CCIs were also included as independent covariates. All of the CCI categories reached statistical significance at p<0.001 except for:

a) Model #1: CCI15 (perinatal conditions; p=0.37)
b) Model #2: CCI15 (perinatal conditions; p=0.36)
c) Model #3: CCI15 (perinatal conditions; p=0.35)

Table 9: Full multivariate model on 30-day total LOS and hospital charges

Characteristic	Full Model: 30-day in hospital mortality		Full Model: 30-day total LOS (log-transformed)		Full Model: 30-day total hospital charges (log-transformed)	
	Odds Ratio	95% CI	Effect Size (β)	95% CI	Effect Size (β)	95% CI
Index admission disposition status						
Transfer: short-term hospital	1.96	1.82 – 2.12	0.216	0.187 to 0.246	0.316	0.276 to 0.357
Transfer: other type of facility	2.71	2.64 – 2.78	0.440	0.430 to 0.450	0.366	0.351 to 0.382
Home health care	1.47	1.43 – 1.51	0.269	0.262 to 0.277	0.239	0.220 to 0.257
Against medical advice	1.10	1.01 – 1.20	-0.344	-0.359 to -0.329	-0.165	-0.195 to -0.135
Age						
18-44	0.30	0.29 – 0.33	0.055	0.045 to 0.066	-0.050	-0.068 to -0.033
45-64	0.63	0.61 – 0.65	0.061	0.055 to 0.067	0.063	0.052 to 0.075
65+	Reference		Reference		Reference	
Gender						
Female	Reference		Reference		Reference	
Male	1.08	1.06 – 1.11	0.020	0.016 to 0.024	0.045	0.039 to 0.051
CCI sum indicator[1]						
0 or 1 CCI	Reference		Reference		Reference	
2 CCIs	1.49	1.38 – 1.62	<0.001	-0.013 to 0.013	0.052	0.038 to 0.067
3 CCIs	1.71	1.58 – 1.84	0.015	<0.001 to 0.030	0.077	0.058 to 0.095
4+ CCIs	1.92	1.77 – 2.07	0.035	0.018 to 0.053	0.080	0.057 to 0.103
Median household income quartile						
1st quartile	0.93	0.89 – 0.97	0.012	-0.004 to 0.029	0.051	-0.006 to 0.107

2nd quartile	0.95	0.92 – 0.99	-0.004	-0.018 to 0.011	0.057	0.003 to 0.110
3rd quartile	0.97	0.94 – 1.00	-0.012	-0.024 to <0.001	0.006	-0.040 to 0.052
4th quartile	Reference		Reference		Reference	
Expected payer						
Private	Reference		Reference		Reference	
Medicare	0.93	0.90 – 0.96	0.010	<0.001 to 0.019	-0.106	-0.122 to -0.091
Medicaid	0.91	0.87 – 0.95	0.060	0.048 to 0.071	-0.066	-0.089 to -0.044
Other	0.89	0.84 – 0.95	-0.024	-0.038 to 0.010	-0.081	-0.116 to -0.047
Bed size of hospital						
Small	1.02	0.97 – 1.07	-0.111	-0.129 to -0.094	-0.362	-0.433 to -0.292
Medium	1.01	0.96 – 1.07	-0.068	-0.085 to -0.051	-0.203	-0.268 to -0.138
Large	Reference		Reference		Reference	
Ownership of hospital						
Government	Reference		Reference		Reference	
Private	0.96	0.90 – 1.03	-0.044	-0.070 to -0.019	0.010	-0.048 to 0.068
Hospital teaching status						
Metropolitan non-teaching	0.99	0.95 – 1.04	-0.061	-0.085 to -0.051	-0.012	-0.070 to 0.046
Metropolitan teaching	Reference		Reference		Reference	
Non-metropolitan	1.18	1.11 – 1.25	-0.131	-0.152 to -0.110	-0.469	-0.524 to -0.413

[1] Each of the 18 CCIs were also included as independent covariates. All of the CCI categories reached statistical significance at p<0.001 except for:

a) 30-day mortality model: CCI7 (circulatory diseases; p=0.05), CCI9 (digestive diseases; p=0.76), CCI14 (congenital anomalies; p=0.58), CCI17 (injury and poisoning; p=0.02), CCI18 (factors influencing health access; p=0.13)
b) log(LOS) model: CCI11 (complications of pregnancy and childbirth; p=0.10), CCI15 (perinatal conditions; p=0.88)
c) log(charges) model: CCI9 (digestive diseases; p=0.11), CCI15 (perinatal conditions; p=0.01)